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Metaphors of industrial rationality: the social construction of electronics policy in the United States and France

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For a generation social scientists have located culture outside the boundaries of rationalized institutions. The national character approach linked national policy preferences to shared character traits, suggesting that a national predisposition to authoritarianism would elicit authoritarian regimes (Almond and Verba 1963; Inkeles and Smith 1974; Bell 1980). In that framework culture was an individual-level variable. Structural functionalism, by contrast, situated culture in institutions but divided cultural institutions (integration and latency functions) from instrumental ones (adaptation and goal attainment). In that framework cultural institutions (education, the arts) were self-consciously and explicitly symbolic and normative.

The recent renaissance of culture in the social sciences has, for the most part, perpetuated this sort of compartmentalization. Culture has come to refer to a set of acknowledged symbolic institutions in modern societies rather than to a pervasive dimension of all modern institutions. Social scientists have been particularly slow to analyze intrumental institutions in cultural terms. When they have done so they have taken the exposé approach of the "organizational culture" school to show that factors such as charisma play a role even in rationalized institutions, rather than treating rationality itself as a social construct.

In the last decade or so a few analysts have situated cultural meaning at the core of rationalized institutions. The Birmingham school has explored science from a constructivist perspective (see also Latour 1987). Neo-institutional students of organizations have charted the social construction of rationalized corporate strategies (Meyer and Rowan 1977; Fligstein 1990). At a more macro-level studies have traced the rise of rationality and the social construction of the modern nation-state (Anderson 1983; Thomas and Meyer 1984). In that vein the present study explores the effects of institutionalized constructions of industrial rationality on the policy-making process in modern nations.

Rationalized meaning systems and public policy

Berger and Luckmann (1965) take a constructivist view of social institutions in all settings, insisting that the social construction of reality operates in rationalized societies just as it does where meaning is organized around mysticism or religion. They reject the notion that rationalized meaning systems symbolize ultimate truths while mystic and religious systems raise false gods, a notion that has made it difficult for modern scholars to treat rationality as a meaning system.

Rationalized meaning systems are organized following the principles of science. Institutions embody laws of cause and effect that are purported to be universal and immutable, laws which are subject to revision when they prove to be wrong (Wuthnow 1987).

Core constructions of rationalized meaning systems are demystified and take the form of commonsense understandings of the world. They share the traits of practical knowledge rather than of religious revelation, representing the nature of the social world not as complex and esoteric but as simple and accessible. Such meaning systems are predicated on the notion that the social world can be understood as a series of mundane cause–effect relationships that can be gleaned directly from experience. As Clifford Geertz argues, "it is an inherent characteristic of common-sense thought . . . to affirm that its tenets are immediate deliverances of experience, not deliberated reflections upon it" (1983: 75). Rationality suggests that the social world is reducible to a series of taken-for-granted relationships and that understanding the world is a process of logic and reason, not of faith. As such, rationalized social systems represent the world as composed of transparent and shallow relationships rather than of underlying, unseen influences such as those of deities and phantoms. But as Geertz insists, such commonsense notions of the universe nonetheless comprise meaning systems:

> If common sense is as much an interpretation of the immediacies of experience, a gloss on them, as are myth, painting, epistemology, or whatever, then it is, like

> them, historically constructed and, like them, subjected to historically defined standards of judgment . . . [It] can vary dramatically from one people to the next. It is, in short, a cultural system. (1983: 76)

Rationalized meaning systems, mundane, transparent, and accessible as they are, represent a world based on common sense. But they do vary by locale. They may link any one of a number of plausible causes to a particular effect, but that cause stands on its shallow defensibility. There must be a recognizable logic behind the cause–effect link, and frequently such links are rendered defensible by the use of natural analogy. As Mary Douglas argues,

> the incipient institution needs some stabilizing principle to stop its premature demise. That stabilizing principle is the naturalization of social classifications. There needs to be an analogy by which the formal structure of a crucial set of social relations is found in the physical world . . . When the analogy is applied back and forth from one set [of] social relations to another and from these back to nature, its recurring formal structure becomes easily recognized and endowed with self-validating truth. (1986: 48)

My goal here is to explore the nature of the institutionalized logics of industrial policies in the United States and France. Those logics are historical constructs with roots embedded in social institutions. That is, over the past hundred years or so prevailing institutions in nations that experienced rapid industrial revolutions were constructed as the cause of growth. France and the United States credited existing institutions with their industrial takeoffs. They constructed logics of progress around prevailing institutions, and then deliberately applied those logics to promote the growth of new industries.

By looking at electronics industry policy I hope to show two things. As Mary Douglas suggests, both the United States and France constructed logics of progress based on natural analogies. In the United States the logic was that market selection effects economic rationality and in the aggregate results in growth. The analogy was to natural selection in the animate environment – to the survival of the fittest. The French analogy was to a biological system, with a central entity (the brain) coordinating the activities of all of the parts to achieve survival and growth. So first, in the American scheme the failure of market mechanisms would be seen as responsible for economic irrationalities, whereas in France it would be the failure of central coordination that would have this result. Second, those constructed logics of industrial rationality shape policies governing new industries, such as electronics. The United States and France had very different notions about how to stimulate growth in the sector, and what to guard against.

Constructing high technology growth

Recent policies designed to spur the growth of the high technology sector vary widely by country. In each country high technology policies bear a striking resemblance to the policies used to stimulate growth in an array of other sectors. The United States stimulates market mechanisms while French bureaucrats plan and orchestrate industrial development. I will argue that those strategies are not the result of the persisting administrative capacities of these nation-states (Skocpol and Finegold 1982; Krasner 1984; March and Olsen 1984) because in many cases new administrative structures were adopted to install these policies.

Instead I will argue that existing growth policies constructed fundamentally different notions of economic growth in these two countries. Because policies had designated different causes of growth, these countries installed different policies to effect those causes when they sought to promote the growth of electronics. After a brief sketch of traditional industrial policies in these three countries I review the strategies used to promote electronics between 1960 and 1980.

Space limitations prohibit a full comparison of the relative merits of this constructivist approach and of more traditional interest group approaches (pluralist, rational choice, and neo-Marxist variants), but I want at least to describe the advantages of the constructivist perspective. Broadly speaking, institutional studies that chart consistent national policy styles over long periods of time have undermined the power of interest group approaches by showing that in comparative perspective France, for instance, tends to adopt the same policy strategies again and again. The French (or the British or Brazilians) tend to choose the same solutions no matter who prevails in political battles. What those studies have shown is that national policy styles are quite persistent over time, even across regime changes. They suggest that different countries choose among mutually exclusive sets of alternatives when they attack a new problem. In short, interest group conflicts would appear to decide which of several similar strategies will be pursued within a nation, rather than challenging the broad logic of public policy. And it is true that in the United States, for instance, the left and right debate *how* to fortify market mechanisms, but not *whether* to use market enforcement or state industrial planning. The constructivist perspective offers a way to understand the broad regions of consensus within nations that underlie stable national policy styles.

Traditional industrial strategies

The United States

America's first policies to regulate industry were designed to protect the economic liberties of citizens. The two main prongs of American industrial governance, antitrust legislation and industry regulation, aimed to guard economic freedom (Wilson *et al.* 1980: vii). The logic of antitrust policy, beginning with the Sherman Antitrust Act (1890), was that the state had a duty to shield firms from predatory competitors. The Act to Regulate Interstate Commerce (1887) which established the first of many federal regulatory agencies aimed at preventing discriminatory pricing practices that could destroy small firms. As industrial growth progressed these government interventions, designed to guard economic liberty, were constructed as a cause of America's industrial takeoff and soon became a positive prescription for growth. In the nineteenth century the corruption of federal schemes to aid industry had galvanized Americans against interventionist policies, and market enforcement was soon equated with *laissez-faire*. As Andrew Schonfield argues, a series of changes in the last quarter of the nineteenth century led Americans away from a belief in the capacity of states to promote economic growth directly and toward "the view, shared by both political parties, of the natural predominance of private enterprise in the economic sphere" (1965: 302). In the emergent American construction of progress markets were ultimately rational, and public policies supporting markets represented an effort to preserve natural economic conditions. Natural selection became the underlying rhetoric of this form of industrial rationality. Free markets would select the best firms for survival, in the aggregate producing the highest possible rate of economic growth.

France

The organization of the French state at the time of industrialization was another thing altogether. France had prospered and grown under a strong centralized state that could supply a large standing army to rebuff continental invaders (Anderson 1974). State centralization had been the key to France's military successes under feudalism, for it allowed the monarch to suppress local groups in the national interest. Thus industrialization occurred under the auspices of a strong and interventionist state. Louis XIV's finance minister took measures to centralize control over the economy in order to orchestrate growth, and Colbertism was born. In the nineteenth century the French state designed and built a centralized transportation network of highways, canals, and railways (Adam 1972; Pilkington 1973). As industrialization progressed the French bureaucracy assumed control over an array of key industries, from tobacco to porcelain to shipbuilding, whenever private control threatened to bankrupt them (Zeldin 1977: 104). The state nationalized key firms and industrial sectors to ensure that they would be well run, from the national passenger train system (SNCF) to Renault. Those policies were based on the analogy of biological functionalism, in which the organism could not survive and prosper without a complete set of healthy organs (read industries). By contrast, other countries with economies the size of France's have tended to choose a few industries in which they enjoy competitive advantages to support.

The second part of the biological analogy involves state orchestration of industrial growth. Since the Second World War state planners have pursued a new version of Colbertism by coordinating development under a series of five-year plans. Indicative planning has involved elaborate sectoral growth projections and selective interventions to meet national goals (Cohen 1977). The logic of this system is that the state should "mobiliz[e] private interests in the service of public ambitions" such as growth (Hayward 1986). The emergent French understanding of growth revolves around a central state that coordinates the self-interested actions of private entrepreneurs toward national ends. In this scheme the pursuit of self-interest in free markets threatens, without state oversight, to undermine the collective good. The implicit analogy is to a biological system, with a single brain (the state) orchestrating the different parts to achieve growth.

> The essential French view, which goes back to well before the Revolution of 1789, is that the effective conduct of a nation's economic life must depend on the concentration of power in the hands of a small number of exceptionally able people, exercising foresight and judgement . . . The long view and the wide experience, systematically analyzed by persons of authority, are the intellectual foundations of the system. (Schonfield 1965: 72)

After the Second World War both the United States and France recognized the military and industrial potential of electronic miniaturization, and both governments committed massive resources to research and development. Their strategies were shaped by these national constructions of industrial rationality in palpable ways. The United States consistently tried to stimulate market mechanisms by offering incentives to existing firms and encouraging market entry. French bureaucrats tried to rationalize the industry from above by restructuring firms, concentrating research and production expertise, and discouraging the entry of new firms.

American electronics policies

The United States created several new policy instruments to promote the development of the electronics industry, but adhered to the same principles of market enforcement and stimulation that it had used since the nineteenth century. That is, institutional structures were changed to promote the electronics industry, but in an effort to apply the traditional principles of natural selection by market forces. New policy strategies resembled traditional strategies not because they were pursued through old administrative channels, as institutionalist approaches to public policy suggest, but because they drew upon institutionalized constructions of economic rationality.

My argument proceeds from the contention that the received wisdom about American industrial policy (the United States has no industrial policy) is mistaken (Magaziner and Reich 1982; Tyson and Zysman 1983). First, American regimes have consistently called their own strategies *laissez-faire* or non-interventionist, arguing that by enforcing market mechanisms they are merely preserving the natural economic order. Yet economists point out that there is nothing natural about market enforcement, which interrupts a tendency for industries to become concentrated in order to achieve stability, economies of scale, and coordination. Second, American regimes are thought not to practice "industrial policy," which has come to mean strategic interventions in particular sectors to promote growth there (cf. Katzenstein 1985). In fact American governments have practiced "industrial policy" since the years after the revolution in the form of stock subscriptions in firms ranging from banks to breweries (Lipset 1963), in the form of land grants to canals and railroads (Kolko 1965), and in the form of research funding and strategic purchasing policies under the auspices of such agencies as the Defense Department (Hooks forthcoming). More broadly, policies to effect market pricing mechanisms and competition *are* industrial policies; in Aaron Wildavsky's words "there is no such thing as not having an industrial policy" (1984: 28).

Since the 1950s federal agencies have promoted the development of the electronics sector with policies designed to foster market competition, by encouraging market entry and discouraging monopolistic pricing and trade practices. While those policies have been pursued independently by different agencies, they constitute a coherent if not coordinated effort to effect growth by enforcing market mechanisms. They have deliberately located authority over the industry in market mechanisms rather than in the federal bureaucracy by limiting the federal role to that of a consumer, or referee, within a free market. Federal agencies have never aspired to establish a central research laboratory, to dictate to firms, or to nationalize the sector (as in France) despite the fact that the state has been the largest consumer of electronics goods.

The market model for R & D

In the years after the Second World War it was clear to the scientific community that electronic miniaturization was within reach, and would have a wide range of military and industrial uses. Yet the Department of Defense did not consider using the national-laboratory model of research and development successfully used at Los Alamos, New Mexico, on the Manhattan Project. Instead federal agencies contracted with private laboratories to carry out their research projects. In the postwar period the federal government spent more, as a proportion of gross national product, on research and development than any other government in the world (Asher and Strom 1977).

The decision to give technology development first priority in the postwar period was motivated in part by the belief that technological superiority was a military necessity. A 1945 report from the United States Office of Scientific Research and Development presaged an expanded public role in technological development: "The Government should accept new responsibilities for promoting the flow of scientific knowledge" (Bush 1945: 3).

But instead of building a national laboratory or allocating a single research grant to one large laboratory in order to concentrate scientific expertise, the armed forces stimulated competition among a number of private laboratories in order to develop the technology. The army, navy, and air force competed to find the best approach by financing research on entirely different miniaturization technologies (Borrus 1988). In the late 1940s the army financed a project to improve conventional technology in electronics, and the navy picked up the project in the early 1950s under the name "Project Tinkertoy" (Golding 1971). In 1953 the air force tried to get Department of Defense support for integrated circuit research, and in 1957 it finally received $2 million to finance a "molecular electronics" research at the Westinghouse laboratories (OECD 1968). Meanwhile the navy was supporting the alternative "thin film" technology in private research laboratories, and in 1961 awarded a large grant to IBM to develop production potential (Kleiman 1966). At the same time (1958–64) the army was financing research on the micro-module approach to miniaturization in the laboratories of RCA. By the late 1950s laboratories across the country were racing to find new ways to miniaturize electronics components (Borrus 1988).

Major breakthroughs came at Texas Instruments, where Jack Kilby produced a working integrated circuit in 1958, and at Fairchild which soon afterwards developed a technique for mass-producing integrated circuits. While both breakthroughs came under private research funding, the armed forces' strategy of stimulating research competition by awarding large grants to competing laboratories was credited with the success. Federal funding had kept both of these laboratories alive, but both had the foresight to finance the patentable stage of research privately (Golding 1971; Asher and Strom 1977).

The Department of Defense had deliberately supported competing lines of research in private laboratories during the 1950s and 1960s. They refused to side with one scientific team or another, instead letting the competitive market sort out which technology would prevail. In those years the French government had chosen to pursue only germanium technology, with the result that they were most advanced in that field but had virtually no experience with competing technologies.

Inventing a market for semiconductors

By 1961 Texas Instruments had completed a working prototype computer that was based on integrated circuits. Integrated circuit technology was still extremely expensive, and the Department of Defense (DoD) now sought to bring the price down so that it could use the technology in a wide range of applications (Golding 1971). DoD and NASA adopted a demand side approach to stimulating the development of production technology and the growth of industrial capacity. In short, federal agencies decided to underwrite the cost of the production learning curve rather than wait for the private market to do so. In 1962 federal purchases accounted for 100 percent of integrated circuit sales, valued at $67 million (McKinsey and Company 1983; Henderson and Scott 1988: 52).

The Department and NASA saw important weight advantages for the use of integrated circuits in their new Minuteman II missile and Apollo programs, and they expected military and aerospace applications to proliferate as integrated circuit technology improved. They pursued two strategies to stimulate growth. First, they ordered the technology for every application they could think of, even when the resulting weight reductions over transistor technology did not justify the extra cost (Tilton 1971). Within a few years the armed forces were demanding the technology in seventeen different defense systems, from radar to guided missiles (Asher and Strom 1977: 74). NASA and DoD put out enormous contracts for integrated circuits with the explicit aim of developing more efficient production techniques. As early as 1962 a trade journal noted that avionics research and procurement proposals now demanded the new technology:

> A small but increasing number of proposal requests for studies, and in certain cases hardware, specify microelectronics – at times when the value of its use is dubious . . . not to have a microelectronics capability about which to boast in equipment proposals, is to risk one's chances of winning contracts. (Miller and Piekarz 1982)

Second, they deliberately spread the contracts among multiple suppliers, in a DoD strategy known as "multiple sourcing," in order to stimulate competition among firms rather than concentrating purchasing power to achieve economies of scale and the concentration of expertise in a single firm. In 1962 the Department awarded Texas Instruments the original Minuteman II development and pre-production contracts, with Westinghouse as a principal subcontractor. In 1963 the Department signed contracts with Texas Instruments and RCA for large quantities of integrated circuits, for which they agreed to pay about $100 apiece or roughly three times the market price (Golding 1971; Asher and Strom 1977: 45). In the same year NASA ordered some 200,000 integrated circuits, most of which were provided by Fairchild.

The Defense Department strategy for stimulating production advances worked. Between 1962 and 1967, when defense procurement accounted for over half of all integrated circuit production, the unit price declined from $50 to $3. The air force attributed the development of integrated circuits and the rapid growth of the industry to this strategy of market stimulation. An air force document of 1965 argued that the expansion of the industry resulted from "a combination of wise policy direction by the Department of Defense; initiative, stimulation, and dynamic management by the Air Force Systems Command [the largest federal consumer]; and spirited response by industry" (quoted in Golding 1971: 45).

These policies also successfully encouraged market entry by new firms. Between 1966 and 1973 alone over 30 new integrated circuit firms entered the market (Borrus 1988: 56).

Enforcing market competition through antitrust

In the early phases of integrated circuit development federal policy was to stimulate competition by offering private firms incentives to invent new hardware and new production techniques. In the years since the late 1960s federal agencies, particularly the Defense Advanced Research Projects Administration and NASA, continued to finance technological development by funding research efforts in competing laboratories, yet antitrust policy gained a higher profile in the electronics sector.

Even in the earliest years of the integrated circuit industry antitrust policy played an important role in industry structure. Why didn't IBM and AT&T compete directly in semiconductor production? The Justice Department had successfully sued IBM for antitrust violations associated with requiring its computer customers to buy computer cards from IBM and not from competing firms in 1932, and in 1949 it had sued AT&T for pooling patents with General Electric, RCA, and Westinghouse to prevent market entry by new firms (Soma 1976). IBM understood that competing with its suppliers in the components industry might lead to further antitrust litigation. AT&T's Western Electric division was prohibited from selling any output (for example, integrated circuits) to commercial customers as a result of the 1949 suit, which effectively kept it from getting into that business (Soma 1976). In short, competition among small firms was fostered during the period by "antitrust constraints on potential entry by electronics giants IBM and AT&T into the open market for semiconductor devices" (Stowsky 1989: 245).

Despite its precautions in integrated circuit development, by the late 1960s IBM had become the focus of computer industry antitrust litigation under the Sherman and Clayton Acts, which prohibit efforts to restrain trade, attempts to monopolize industries, and acquisitions that would produce monopolies (Fligstein 1990). Prohibitions against acquisitions that would produce monopolies were, by most accounts, prophylactic in that they prevented industry giants from considering mergers. Restrictions against the restraint of trade were the focus of litigation.

In 1969 the Justice Department filed suit against IBM for restraining the trade of its competitors, principally by bundling software, hardware, and support services and requiring its clients to purchase all three (Soma 1976: 35). After thirteen years of litigation the Justice Department dropped the suit, having effectively put an end to the practices it objected to (McClellan 1984: 61). The longstanding IBM suit stood as a warning to other manufacturers that the Department would not tolerate practices that amounted to the restraint of trade.

IBM has suffered a number of private suits as well. In 1969 Control Data Corporation (CDC) sued IBM for deliberately trying to undermine CDC's business. On the eve of the introduction of a new high-end CDC machine IBM had announced a competing machine which was not yet on the drawing board, causing CDC to drop its price dramatically and to lose a number of orders. In January 1973 the suit was settled out of court for over $100 million worth of subsidies and guarantees (Soma 1976: 37; McClellan 1984: 59–61). At about the same time a number of firms brought suit against IBM for restraining trade by not making system specifications available to competing producers of peripherals and components. Advanced Memory Systems, Telex, and Memorex, as well as a number of smaller firms, won such suits. The Justice Department had opened the way for such suits with its early litigation against IBM and AT&T. The logic of their electronics industry litigation was that large firms in this growing industry must not inhibit market entry or successful competition from their smaller rivals.

The outcome of this set of policies has been easy entry into the semiconductor field and substantial competition among small entrepreneurial firms. This was evident from early on in the semiconductor industry:

> Unlike integrated circuit production in Europe and Japan, which was dominated by large, vertically integrated electronics systems manufacturers, IC production in the United States came to be dominated by a set of independent "merchant" firms whose primary business was the manufacture and open market sale of semiconductor devices. (Stowsky 1989: 245)

In short, at each stage of development American policy toward the electronics industry has been to encourage competition among firms and facilitate market entry. The idea of direct public involvement in production, even in a sector so dominated by public procurement, was anathema. As Andrew Schonfield argues, "Among the Americans there is a general commitment to the view, shared by both political parties, of the natural predominance of private enterprise in the economic sphere" (1965: 302). The logic of American policies was that natural market selection mechanisms serve as a rationalizing force that transforms individual initiative into macroeconomic growth.

Mimicking Japan

While in the 1960s and 1970s these policies were validated by America's dominance of international markets, by the early 1980s it became clear that Japan was overtaking the United States in certain key areas, particularly semiconductor production. The Japanese had gained the lion's share of the market with an industrial strategy based on government sponsorship and industry collaboration on research and development. These experiences tended to disprove American notions of market rationality, at least for the semiconductor sector, and Americans tried to effect the Japanese prescription in several settings. US Memories, a California-based memory chip cooperative involving seven major computer manufacturers, was to expand US production capacities to ensure a steady supply of chips but the venture fell apart in early 1990 over disagreements among the firms. The Austin-based Sematech is a joint venture of 16 high-technology firms; it was established in 1988 to develop and diffuse new semiconductor production techniques that would keep the United States at the cutting edge of the industry. The group has received $100 million annually in federal funding for 1989 and 1990, which amounts to about 40 percent of its budget. The venture has attracted several hundred scientists, yet industry analysts maintain that it is grossly underfunded as compared to the research efforts mounted by Japan's MITI (Vaughan and Pollard 1986; Stowsky 1989). These collaborative efforts represent a response to the apparent failure of "natural selection" in the semiconductor industry. The Americans' capacity to use the decline of the semiconductor industry to disprove that "natural selection" would work suggests that rationalized meaning systems indeed consist of sets of means-ends designations; it suggests also that these are highly susceptible to revision when the means they designate appear to fail (Wuthnow 1987).

French electronics policies

If American electronics policy was motivated by a belief in the efficacy of market processes, French policy was motivated by the belief that economic rationality would result from state orchestration of the efforts of private actors. As Richard Nelson puts it, "The tradition of a strong civil service actively engaged in encouraging, protecting, and subsidizing particular industries goes back to the Bourbons. It was not unnatural, therefore, for the French to assume that the government should play a major role in guiding industrial development" (1984: 33). French policy could hardly have been more different from American policy. Where the Americans outlawed mergers the French brokered them. Where the Americans refused to favor particular firms in their procurement procedures, the French designated "national champions." Where the Americans sought to stimulate competition and market entry the French sought to eliminate both. Where the Americans made agreements to make product competition illegal, the French encouraged it.

French research and procurement policies did not aim to multiply efforts to reach a particular goal, but to concentrate them under a rational central plan. When it came to research and development, this meant that policies supported research into one promising technology rather than competing technologies. When it came to production and marketing it meant that policy was aimed at concentrating the electronics sectors rather than encouraging competition. The "national champion" strategy pursued by the French has involved inducements for competing firms to combine, through horizontal mergers and restructuring; this has created large firms specializing in different high technology products that face no competition within France. Part of the logic was that France should develop every pertinent sector of the computer industry rather than specialize in a particular product.

France has seen three principal national electronics plans since the 1960s: the Plan Calcul (1966), Giscard d'Estaing's internationalization strategy (1977), and La Filière Electronique (1982). Each was designed to restructure the industry, in order to concentrate electronics capacities in parallel "national champions" that would specialize in mainframe machines, office computers, telecommunications equipment, and semiconductors. The first plan was to develop national self-sufficiency, the second to expand international collaborations to take advantage of technology transfers, and the third was to nationalize key firms to bring them under greater state control. The common logic of these three plans was that (a) state orchestration could rationalize the efforts of individual firms whereas free markets would produce industrial chaos (the brain analogy) and (b) the vitality of the entire industry was dependent on the vitality of every subsector (read organ) and thus state policy involved a plan for each subsector (the biological functionalism analogy). The latter was achieved largely through sectoral consolidation (merging establishments with similar products) and market apportionment (allocating markets for particular products to particular firms).

The single-strategy approach to research

Before the 1960s the French electronics industry enjoyed substantial success. In 1960 Machines Bull still rivalled IBM in the international market for computers, having exported machines to the United States since 1950 under a licensing agreement with Remington Rand (Mazataud 1978: 17). French success had come with their advances in germanium technology, which had been promoted by a government research and procurement strategy that concentrated efforts on that one technology. By demanding germanium technology in weapons in the 1950s, and funding research only on that technology, the French state had made France the world leader in germanium technology.

The French strategy of permitting civil servants to choose a single technology to invest in would have proven successful in the long run if integrated circuit breakthroughs had not eclipsed germanium technology. Instead, the events at Texas Instruments meant that government policy would have to change course.

What pushed the French government to develop a more ambitious and interventionist policy for the electronics sector was an American embargo on the export of mainframe machines to France – machines which the French government had wanted to use in its nuclear research program. That action catalyzed existing French sentiments in favor of developing every vital industrial sector rather than specializing in certain goods and technologies – what I have been calling the functionalist analogy. The French government now felt that dramatic action was needed to bring its computer industry up to speed, so that it could supply the military and industries that depended on computers. The concurrent acquisition of France's computer industry leader by the American firm General Electric reinforced those sentiments.

To ensure the vitality of the French computer industry the state introduced the "Plan Calcul" in 1966. Under the plan the state established a national laboratory in Le Chesnay, outside of Paris, dubbed the Institut Nationale de Recherche en Informatique et Automatisme (INRIA). INRIA was placed under the direct control of the planning authority and by 1968 was receiving half of France's 9 million franc research and development fund for semiconductors as well as the bulk of the nation's computer research funding (Mazataud 1978: 29–30).

Private research and development contracting differed in several ways from that in the United States. First, the state's Délégation Générale à la Recherche Scientifique et Technique concentrated financing in four large laboratories by contracting directly for research, rather than encouraging competition for research contracts by putting out requests for proposals as the armed forces did in the United States (Tilton 1971: 128–31). Second, the four principal laboratories, INRIA and three private laboratories, pursued research on different products rather than competing to find the best technology for a particular product. The SESCOSEM laboratory, for instance, specialized in components research while INRIA specialized in mainframes. Research programs were coordinated to the end of developing all of the technologies necessary to build computers. In each sub-field planners and scientists chose a single technological strategy to pursue.

Production: the "national champion" approach

The centerpiece of the Plan Calcul of 1966 was an effort to restructure the computer industry to produce sectoral "national champion" firms. Planners coordinated agreements among the major all-French manufacturers, excluding Machines Bull because of its American ties, and restructured firms to consolidate the industry. In December, under the auspices of the plan, an accord was signed between the state and the three largest French-held computer companies: Schneider, the Compagnie de Télégraphie Sans Fil (CTSF), and the Compagnie Général d'Électricité (CGE), establishing the Compagnie Internationale pour l'Informatique (CII). Under the plan the state promised 420 million francs for research and loan guarantees, totaling 500 million francs, in return for a promise that by 1972 CII would produce four mainframe computers (Mazataud 1978: 30). Over the next few years state planners brokered further mergers, to increase the concentration of the mainframe industry. In 1968 the independent Thomson acquired CSF and their 77 percent share of CII, and in 1970 CII absorbed Sperac. By the early 1970s Thomson-CTSF controlled the lion's share of the industry, including majority interest in CII.

State planners did not stop at designating a national champion in the field of large computers but went on to dictate what that firm would produce. As John Zysman (1977) points out, planners prevented CII from exploring market niches by decreeing that it would produce medium-size mainframe computers for industrial and military purposes that would compete directly with IBM's product line.

The Délégation replicated the Plan Calcul strategy to effect horizontal mergers in the peripherals and components (Plan des Composants) sectors in 1966 and 1967 respectively, in both cases by detaching subsidiaries from their parent companies and combining them with competitors in the same product line, so creating the new SPERAC which would produce peripherals, and SESCOSEM which would produce components. As with CII, state planners decided what these groups would manufacture. The Délégation had decided that CII would build machines based on Texas Instruments' semiconductor components, and as part of the overall plan decided that SESCOSEM should duplicate the TI line of components with the aim of supplying CII with French-made semiconductors. SESCOSEM had no particular strengths in producing semiconductors and was unable to achieve TI's economies of scale, thus the firm continued to require substantial state subsidization (Zysman 1977: 149).

The planners' strategy of dividing up product lines to eliminate competition among French manufacturers received another boost in 1969 when Thomson-CSF and CGE (a CII participant) signed a treaty of "non-belligerence"; in it they agreed to divide up the electronics market so that they would not be in direct competition in any major product line. CGE was to focus on telecommunications and energy devices and Thomson on information technology and business and industrial use electronics equipment (Mazataud 1978: 39).

The Délégation's initial marketing strategy was simple. They decreed that government agencies and corporations would purchase CII products rather than shop for computers on the open market. That strategy was predicated on the market power of the French state, where the railways, air lines, utilities (including nuclear power plants), and telecommunications industries are nationalized (Nelson 1984: 34). French firms were thus guaranteed a 40 percent share of the domestic market for computers and related equipment.

French planners had four principal tools that helped them to gain the compliance of firms in these plans. First, they promised to subsidize firms that followed their wishes, or to make up operating deficits if those firms did not turn a profit. Second, they guaranteed a market to those firms by providing public agencies and other "national champion" firms with incentives to buy exclusively from them. Third, they controlled access to credit. Fourth, they controlled trade barriers to protect particular domestic industries. The ability of the French state to control so much of the environment made it easy for state planners to induce firms to participate in their grand schemes.

The internationalization strategy

By the mid-1970s it was clear that the Plan Calcul's efforts to build internationally competitive firms in each high technology sector had not been successful. The French could build their own computers and components, but not at competitive prices. Giscard d'Estaing's administration blamed the effect on the Plan Calcul's protectionist policy on technology transfers. Now the Government sought to develop joint ventures in each technical area to bring technological advances to France. The Government forged an alliance between CII and the American–French venture Honeywell Bull (the latest incarnation of the General Electric–Machines Bull marriage) with a 53 percent French stake, and brokered joint ventures in components development between Thomson and Motorola; between Matra, Harris, and Intel; and between St Gobain and National Semiconductor (Rushing and Brown 1986: 74). Those components industry collaborations introduced a degree of competition in response to the perceived success of competition in the American semiconductor industry. But the policy of designating three French components firms stopped far short of encouraging market entry; it was to be short-lived, and it did not extend to other sectors, where the national-champion approach still prevailed (Brickman 1989).

La Filière Electronique

The Socialists reorganized the electronics sector once again in 1982 under a five-year plan called la Filière Electronique, which nationalized important firms as it restructured the industry. Mitterand nationalized CGE, St Robain, Rhône-Poulenc, and Thomson, and acquired a majority interest in Matra and a 75 percent interest in CII-Honeywell Bull. Restructuring again involved concentrating expertise in every electronics sector to create a complete set of healthy interdependent firms. Here again the biological analogy fits; "filière" refers to the entire range of activities associated with a particular technology and the plan coordinated every sector, from components to aerospace electronics to software. State planners again redrew boundaries among electronics firms to create a national champion in each sector, in an agreement dubbed the "Yalta of Electronics." It called, for instance, for CGE to trade its consumer and components division for Thomson's telecommunications division in order to concentrate expertise on those technologies (Langlois *et al.* 1988). Thomson was to specialize in components (for example, semiconductors) and professional electronics, CGE in telecommunications equipment, Bull in computers and office equipment, and so on (Brickman 1989).

The nationalizations of the early 1980s were part of the Socialists' overarching plan to socialize the French economy, yet they had surprisingly little effect on how managerial decisions were made because the state had already played a central role in industry decision-making. Nationalization was just another approach to applying the logic of biological-functionalism to the economy. State planners (in the role of the brain) made key decisions governing technology and industry structure with an eye to maintaining a self-sufficient set of healthy interdependent monopolistic firms (in the roles of vital organs). In the eyes of the French, state orchestration remained the solution to the problem of rationalizing and giving direction to the inchoate actions of self-interested entrepreneurs.

As the economic integration of Europe in 1992 looms large on the horizon French policy has taken a more international flavor. European governments have established a number of joint ventures among competing establishments in an effort to achieve the economies of scale that American firms enjoy, and the benefits of collaborative research and development efforts characteristic of Japanese industry. France has taken a leading role in establishing joint ventures in an array of high technology sectors, in what appears to be an extension of its past biological functionalism strategy to Europe as a whole. In 1989 the European Economic Community announced a $5 billion Joint European Submicron Silicon program, known as Jessi, which brings together European talents with the aim of developing a 64 megabyte chip (currently the largest chips are four megabytes). The principal firms involved are France's Thomson, Philips of the Netherlands, and Germany's Siemens, and the French state has committed more than its share of funding. Other international ventures include Race ($1.5 billion for telecommunications), Esprit (a 14-nation collaboration in integrated circuit design), and Eureka-A (a 19-nation collaboration on 297 high technology research projects).

In short, the French strategy for promoting the growth of electronics was, like the American, stimulated by perceived military needs. But that is where the similarity ends. Since the 1960s the French state has played a strong role in the development of the industry, not only by providing substantial research and development funding, but by repeatedly restructuring firms and telling them what to make and whom to sell it to. If the logic of American policy was that market selection would rationalize the self-interested behavior of individual firms, the logic of French policy has been that only central state coordination of industry could rationalize individual action and guide markets in directions beneficial to the nation as a whole. Moreover, the French have repeatedly pursued the policy of creating national champions and undermining markets. This has happened despite the widespread belief that European electronics firms have lagged behind the United States and Japan precisely because countries such as France have not "nurtured small, innovative companies like those that abound in Silicon Valley. Instead, Europe has relied for its advances on big, slow-moving national champions that grew lazy in protected domestic markets" (Greenhouse 1989). Even the most recent international collaborations have replicated that strategy.

Conclusion

In modern nation-states the means–ends designations that are institutionalized in public policies vary widely. Under the banner of progress governments try all sorts of policy instruments, from breaking up AT&T to nationalizing Renault to privatizing the post office. I have been arguing that the broad logics undergirding such moves can be best understood as part of institutionalized constructions of economic rationality. Different nations pursue broadly different policy strategies because they hold different understandings of the logic of industrial growth, of how the economy works. Those understandings are roughly isomorphic with existing policy strategies as long as those strategies appear to be effective. When countries seek to promote the development of new industries they think in terms of the logic of existing policies. Unless those policies are in the process of conspicuously failing, as during recessions, nations tend to replicate their logics in new policies. In short, as modern social institutions organize growth in one way or another, via what Chalmers Johnson calls "market-rational" or "plan-rational" strategies for instance, they symbolize particular causes of growth. When they attack new problems they try to simulate those causes.

In the cases of American and French policy the underlying logics of industrial rationality draw on natural analogies, as Mary Douglas suggests. In the United States natural selection has become the prevailing metaphor for industrial rationality, and growth strategies have sought to create competitive situations and to stimulate market entry. In sharp contrast French policy activates a biological functionalism analogy in which the national economy can prosper only under the direction of central expert planners who can coordinate the inchoate actions of individual firms and intervene where market processes lead to outcomes that are irrational in the long run. A core element of that strategy is the notion that an economy must contain all of the parts necessary to self-sufficiency. That stimulated the French to initiate the Plan Calcul, to ensure the nation's capacity to produce computers. It also motivated repeated efforts to create a national champion in each sub-sector of the industry, rather than, following the lead of Korea or Japan, to develop particular market niches where the nation had a competitive advantage.

In both cases it is clear that constructions of industrial rationality are not static but are responsive to feedback, as Robert Wuthnow (1987) suggests they should be as part of rationalized meaning systems. The United States has begun to experiment with novel collaborative policies in response to the American decline in the field of semiconductors and the apparent success of Japan's collaborative strategies. It remains to be seen whether collaborative ventures will survive, but they certainly signify the constructed nature of notions of economic rationality. French policy has changed direction several times, from insularity to internationalism to nationalization and again to internationalism. New policies were installed when it became clear that existing policies were not having the desired effect, that is, when events disproved the logic of policies already in effect. Yet in the French case it was not the core logic of *planification* that was altered with each new scheme, it was the relationship to the wider international market.

The electronics industry has provided one example of how institutionalized social constructions of rationality may shape future policy choices. History influenced American and French policy, but not by leaving these countries with peculiar configurations of interest groups or different state organizational apparatuses. Instead history offered different social constructions of industrial rationality, in the form of substantially different sets of public policies that accompanied industrial prosperity. Future studies of the symbolic content of modern rationalized institutions promise to address two problems in the social sciences. First, the images of industrial rationality discussed here offer a way to understand persistent national policy styles that other paradigms of public policy have not been able to explain. Second, the study of symbolism in rationalized institutions promises to redress the current tendency to treat only "symbolic" (read non-instrumental) institutions as cultural, which has had the unfortunate consequence of preventing students of modern culture from analyzing the construction of rationality itself, which lies at the core of modern meaning systems.[1]

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